SCIENCE

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THE TECHNICAL APPLICATION OF MICROORGANISMS TO AGRICULTURE[1]

OUT of a period extending over several centuries, there were developed many scientific and unclassified forces which gradually but with positive progress focused in the person of Pasteur. They were often indefinite, possibly crude, and not infrequently speculative. In the mind of Pasteur they were digested, assimilated, reconstructed and confirmed, reissuing from him in an harmonious whole. When they emerged they possessed tangible form as directive principles founded upon actual demonstration and specific knowledge.

Fermentation, the great fundamental work of Pasteur, came from his hand with new life and singular pertinency. The vitalistic element advanced by him and founded so thoroughly upon experimental data fresh from his efforts became the pilot. While perhaps in error regarding details, the general truths have stood the tests of time. Pasteur's fermentation has put into the hands of every scientist, whether in the field of plants or animals, physics or chemistry, a truly basic working policy. If extended and modified, moreover, it may furnish the most satisfactory theory for explaining the relationship of many microorganisms to disease, not as the only agent, but one of several.

The comprehensive and basic ideas contained in fermentation permeate every province of practical life, and none to a

[1] "The Lower Organisms in Relation to Man's Welfare," Symposium, Soc. of Am. Bact., Sects. C and K, A. A. A. S., Philadelphia, January 1, 1915.

greater extent than the domain of agriculture.

The applications of fermentations may be followed into the management of the soil, the plants which grow therefrom, and the animals which in turn are fed by them. Microorganisms are the initial agents which work through their dynamic forces and contribute the results of their energy to the cause of agriculture and man. More particularly these activities manifest themselves in the upkeep of the soil or in soil fertility with its complications of elemental reactions, in the growth and diseases of plants, in the nutritional and pathological processes of animals, in the canning, drying, refrigerating, brining and spoliation of food, in the production of wine, beer, bread and vinegar, in the care of water supplies, in sewage disposal, in the manufacture of vaccines and serum products, in public health control, all of which make the profession of agriculture more definite and more scientific.

It is peculiarly fitting to assign to Liebig the synthetic initiative in scientific agriculture, for through him agricultural knowledge was first effectively arranged or systematized, brought out of ignorant obscurity, and placed in line for further and secure development. Although he failed to grasp the full significance of the true rôle of microorganisms in nature, he nevertheless provided the encompassing and essential knowledge which enabled microbiology to find the basis upon which to build its superstructure. In other words, he excavated and placed the stone with the cement, but it was left to Pasteur to prepare the framework of the biological building to be placed upon this foundation. Reverting to the forces which focused in Pasteur, Liebig was probably more successful in converging them than any other scientific investigator.

It is especially easy to trace to Liebig's soil studies those pioneer observations bearing on the formation of such compounds as ammonia, and nitrates in the soil, and such other facts as point the way to a utilizable knowledge of scientific agriculture. He recognized the accumulation of nitrogen in the soil, but failed to conceive, before his death, the nature of the process concerned with its accumulation, whether, as we now view it, symbiotic or nonsymbiotic. In advancing the theory that ammonia was washed from the air by the rain, he did not receive general support because it was only a small fraction of the truth. There was lacking apparently a link in the chain of needed evidence. He wandered into the present overwhelming subjects of plant and animal physiology without fully appreciating the labyrinth of scientific dangers and difficulties he was likely to encounter, but he extricated himself with wonderful tact after surveying thoroughly the entrance chambers and the bearings of the leads into the unknown. No one may have brought to light so many experimental data, demonstrated so many isolated agricultural activities as had Liebig, but they were unbounded, to a degree unrelated, and could not be carried fully and successfully to application largely because they lacked the vehicle of a consistent or logical directive principle. In Liebig's day no guiding hand led the way and this wilderness of observation remained dense and impenetrable, for causes and their consequences must include the processes involved, and all must be determined before true, intelligent and continuous progress can be made.

Pasteur, by an almost intuitive insight into the operations of nature, was the first who could with some authority suggest the possibility that nitrification may be instigated by microorganisms. This was later

verified by Schloesing and Müntz, who by inhibiting the function of bacteria by means of an antiseptic found that nitrates failed to be produced, but, without the antiseptic, nitrates formed normally. This was many years before Winogradski isolated the organisms. However, with the finding of the organisms, it became possible to ascertain the conditions under which they operate most energetically, thus establishing control. This resulted, of course, in the addition of intelligent and valuable practises. Recapitulating, therefore, for the purpose of illustrating a single scientific development and sequence over a comparatively short period of time, it may be categorically stated that Liebig recognized nitrification in the soil; Pasteur's mind and hand furnished the general principle, fermentation, and suggested that this change in soil may be due to microorganisms; Schloesing and Müntz demonstrated the truth of Pasteur's suggestion by the use of antiseptics, and Winogradski completed the task by the isolation of the organisms and the study of their nature.

No more interesting scientific fact can be found than the culmination of centuries of observations and speculation in the classical experiments of Hellriegel and Wilfart. The accumulation of nitrogen in the soil had assumed a reality, even in Liebig's time, and the value of legumes to soil fertility was mentioned by Pliny, but it remained for Hellriegel and Wilfart to relate these facts definitely through the microorganisms in the nodules of leguminous roots. Symbiotic fixation of nitrogen materialized. A new era was introduced for practise, since with the isolation of the organisms by Beijerinck two years later it became possible to demonstrate directly the absorption of atmospheric nitrogen by the nodule microorganisms and further to employ them advantageously in the inoculation of plants, until to-day many thousands of cultures are utilized in the course of a year. If our purpose were mercenary, it could easily be calculated that millions of dollars were added to the wealth of the United States without the exhaustion of any resource. Man's power has increased a hundredfold in this particular alone. It may be safely said that it has already measured to this estimate and its possibilities are still open.

Symbiotic fixation of nitrogen must not be confused with the non-symbiotic. As late as 1885 Barthelot determined the presence of microorganisms in the soil which without association or symbiosis with the plant possessed the power of accumulating nitrogen. In the soil this nitrogen appears available for plant nutrition. While this means of gathering nitrogen may appear pregnant with future inducements, as yet its values are illusive, for little headway has been made in transforming the intrinsic energy into forms of great usefulness. This should not, however, be cause for discouragement, for like the discovery of oxygen, its ramifications are its future for man. Projected applications can not be measured by a score of years, but by centuries, not by present attainment, but by future progress.

The activities of microorganisms in the soil do not stop with the decomposition of nitrogenous organic matter resulting through oxidation in nitrification and perhaps later in denitrification or in the symbiotic and non-symbiotic fixation of nitrogen, for with the fermentation of the ternary compounds there are produced such substances as carbon dioxide and other organic acids which act directly or indirectly upon the mineral constituents and in this manner furnish food for plant growth not otherwise available. Then too there are the sulphur and iron bacteria

which have a rôle to play and others doubtless whose work and values we in our ignorance do not recognize.

Soil in the light of microorganisms may be regarded as a substance having for its basis or groundwork mineral constituents of geological origin to which has been added organic matter. Through the fermentations and changes in the organic matter and the solution of mineral substances incited by microorganisms such products are formed which give to plants their existence. The mineral constituents forming the basis must be those, of course, essential to the construction of vegetable tissues, and the organic matter after decomposition such as will contribute required food. The continuity of the supply is paramount. After all the elements are present and the conditions for microbial and plant life provided, the active or operating machinery of the soil is resident in its microorganisms.

It follows also from the above—a matter of great importance to the microbiologist—that soil types are as variable as their geological formations, the mineral constituents which give them their character, and the organic substances which enter into their fertility. This variability is heightened when to it is added a consideration of the varying amounts of mineral and organic substances present. Soil, therefore, as we have employed the term, can not be interpreted from any one type or several types, but rather specific instances and specific types formed under known conditions. Soil, defined by its structural parts, unless concretely and definitely applied to some type, has no existence, but when so defined holds its physical, chemical and biological factors, harmoniously united in its mineral and organic composition.

The dairy as well as soil offers interest to the agricultural microbiologist.

In a sense it is a veritable microbiological laboratory instituted for commercial purposes. On the other hand, to the dairyman it is a great industry based upon several elemental sciences and other distinctive industries. Furthermore, it is concerned with the preparation of milk and milk products for the consumer. Microbiology is only one support in this extensive food manufacture. Our approach is microbiological and our treatment will be its interpretation from this viewpoint, which has been greatly emphasized during the past twenty-five years.

Cow's milk can not receive full approval without the vital and broad question of disease transmission from the animal at once arising. Although knowledge of the importance or extent was at first extremely meager and indefinite, growth has occurred from the time when Klein wrestled with the probabilities of communicating diphtheria through the blood and milk till the present moment which grants specific information and satisfaction in the matter of the most serious diseases. Tuberculosis has assumed huge dimensions within the memory of most of us, for it came into the limelight of popularity by Koch's discovery of tuberculin, a discovery which alone has paid for all the time and means expended upon microbiology since the days of Schwann. As an illustration of doubt and the stage of dilemma and misty ideas necessary to the decisive solution of all weighty questions, the present furnishes the milk producer and microbiologist with the "dairy septic sore throat." These allusions, however, indicate very slightly how great is the "microbiological purity" of milk as it emerges from the cow.

Then as the milk is exposed to the contaminations of the milker, the air, the utensils and the stable, or as it passes through the paths and by-paths of the milking process—the most crucial undertaking

in reality—it becomes more and more laden with dangers. In the eyes of the milk producer the drawing of the milk from the udder and passing it on to the consumer is fraught at times with insurmountable difficulties. This task is not easy for a trained, intelligent manipulator, so many and diverse are the ways of contamination. Too many who have never drawn a drop of milk from a cow under the practical conditions which surround her find it very simple to lay down regulations. To carry these into effectiveness by force against possible negligence, ignorance, indifference and even criminal wilfulness, only increases the strength of the barrier which separates the controlling and controlled elements.

Other important manipulative processes in the dairy as straining, cooling, pasteurizing, cleansing, may be readily designated as a struggle against the army of microorganisms which has been allowed to enter. This warfare is costly when it proves to be nothing more than the undoing of what has been done. It is the recognition of ignorance and conditions over which control is impossible through any plan devised by man, but it is also the award of inheritance and traditions fostered in former generations and neglected as a lowly pursuit.

In the preceding paragraphs artificially reared babes have been the indicators by which the microbial reactions are determined. We now turn to the adult who seeks security from invasions by microorganisms through the medium of milk. The ages have given to us sour cream butter, properly ripened cheese, various palatable fermented milk drinks. Sweet milk is a source of danger, but time has been beneficial in demonstrating that if milk is started with the right fermentation the element of danger is routed. Accordingly, in the knowledge and practises of the day, it is a simple matter to develop innocuous but dominating cultures of lactic or other organisms which will lend themselves to supplanting and controlling those organisms whose presence is not sought in the cream which makes the butter, in the milk which makes the cheese, in the intestines subject to all sorts of defiling and toxic substances, in milk which leads to koumiss, kephir, yoghurt and other delectable milk beverages. The taste once developed, as that which selects a fine wine, attempts to extend the local manufacture and demands for instance for a Camembert or Roquefort a broader field, for in such products are found the bouquet of a *Penicillium* and other organisms which find response even in an American palate.

The vulgar term "starter" exemplifies the Yankee adroitness in the use of words which hit. It must not be gathered that it is confined to the dairy, for it has been used for yeast in the making of bread, in brewing and wine production, in vinegar manufacture, and elsewhere. The new method employs a starter which is a known culture of microorganisms and the old method employed a starter, under different names, of unknown germ content.

Not only milk, but foods of many kinds command the attention of the microbiologist, and they all in some form concern the farmer. Whether in preservation by drying, by heating, by refrigerating or by brining and the use of preservatives; whether in fermentation leading to some useful end; whether in putrefaction or decomposition resulting in the destruction of the food with or without the production of toxic substances; or whether in those abnormal conditions instigated by disease-producing organisms calling for inspection or public control, microbial processes are involved and microorganisms, the active

agents which are to be fostered or hindered, constitute the pulsating center of effort.

The drying of some foods has been practised haphazardly since very ancient times; the value of heat has long been known to check the advance of decomposition, even long before Spallanzani in about 1770 gave to the world his experiments with the preservation of vegetable and meat infusions; King Solomon kept snow in trenches covered with bushes and leaves through the summer, that he might have it to cool his drinks; the use of chemical substances whether for physical or toxic purposes appears to be of more recent origin. Even though observation had divined relationships and established limited and crude practises, it is a simple truth that the food industries founded upon desiccation, heat, cold and chemical compounds made no headway of significance until it was found that underlying them was the directing general principle: Food would spoil if the microorganisms were allowed to develop; if they were not allowed to develop it would remain practically unchanged. As soon as Brieger was able to point out some of the toxic substances which microbial life produced, this same principle was extended to poisoning of food undergoing decomposition. It was not, however, until the relationship of microorganisms to disease was established that inspection became truly effective, notwithstanding it had been in operation from Biblical times in much the same way as the preservation of food was practised.

I ask you to consider for a moment what economic import is contained in the preceding paragraph. Conceive if you can the amount of dried food, the number of canned containers, the food consumed which has been in cold storage or refrigeration, the value of the preserved or brined products for which you as an individual are responsible during the course of the year; you will then not be surprised at the quantities necessary to stock for one trip a great ship which carries five thousand persons. Multiplying the individual capacity by 100,000,000, our country's capacity is ascertained. What does this mean in terms of the industries indicated? To this add the great reduction in the number of cases of food poisoning together with the elimination of diseases by meat inspection; then may I again ask, is it possible to grasp the full force of what has been evolved by an acquaintance with the forms, functionings and habitats of microorganisms?

It is with peculiar pride that, in passing on to other matters of weight to both microbiology and agriculture I can, incidentally, pay tribute to Professor Burrill, the venerable worker who named the cause of pear blight as early as 1883 when he had no trail to follow; and to Erwin F. Smith, who has contributed so much to the study of bacterial diseases of plants through discoveries and the organization of knowledge in this field even in the face of much German antagonism and criticism. Our national spirit may be pardoned for the moment, while realizing that there are no international boundaries for science. From this work effective methods of control have been formulated and have enabled intelligent handling of such diseases by those concerned.

No province of microbiology even from the very beginnings of this branch of science and also back through its speculative stages of development, has received greater attention or enrolled a larger army of investigators or given more important results than that which is commonly designated as medical, sanitary or hygienic. Its gifts are broader than any industry, greater than those of any profession, and they can be measured only by the limita-

tions of humanity. While pertinent to every aspect of urban life, they are equally valuable to him who finds his work in the country.

Pasteur's mind touched economic problems. As soon as he conceived a problem he projected it to its applications. Fermentation was interesting to him not only as a scientific problem, but because heavy losses were incurred every year from improper management. He was assigned by Dumas to the study of the silkworm disease, conquered it, eliminated it, and made it possible for the silk industry to succeed. He attacked anthrax because it was making ravages among the live stock of France. By his methods of vaccination he was able to control it. He became interested in rabies and in this his unique work developed a treatment which has proved successful. This taken in connection with the introduction of Lister's aseptic and antiseptic surgery unlocked the door to an exceedingly wide field of application. To comprehend it (even by one fairly familiar with it) presupposes human power in excess of that which really exists, for it implies a knowledge of nearly every walk in life. It reaches every point touched by the human hand. In the early eighties many diseases were traced to their origin, the organisms isolated and studied in the light of prophylaxis. Then infectious diseases were a nightmare; to-day we feel they are under control and we rest in the contentment of a victory. Through the labors of the workers beginning with Pasteur followed by Lister, Koch and scores of other notable investigators, the profession of medicine has grown out of its ignorant mysticism into a science; veterinary medicine has found its inspiration, and public health has become a tangible reality.

Of the total number of infectious diseases, those attacking animals form no small part. The economic importance in this respect affects not only the producer, but the consumer as well. Here as in human medicine progress is making. With the later development of serum-therapy as in the case of hog cholera, of vaccines as in the case of black leg and other diseases, there promises to be eventually a time when most of the animal infectious diseases can be either cured or prevented.

We must not forget either that we still have not extended to our rural communities the full meaning of water supply control so satisfactorily operating in cities and towns. There are those who tell us that typhoid fever is a rural disease. This can easily be understood when the conditions generally existing are known. Water supply on the farm concerns not only the farm home and the farm animals, but by its issuing from the farm through the channel of milk, the city home as well. Before improvement is assured, the farm home must adopt safe methods of sewage disposal which are open to it. With the development of these resources; with the accumulation of rural wealth; with the formation of tastes with tone, the benefits now enjoyed by urbanites must extend to the country and carry with them the sanitary and health lessons associated with a knowledge of organisms.

It is easily surmised from the foregoing that only some of the most important microbiological features of agriculture have been treated, and these subjects in a very cursory manner. Furthermore, there is evident in all assertions an attempt to depict a general agricultural development in the light of the development of a single branch of science. Lest I may conclude the paper leaving a false impression behind, I ask your forbearance while I utter a word of explanation. Agriculture is a vast and composite division made up of

many industries, founded upon many elemental scientific pursuits. Science in reality can not be divided and subdivided, but is intricately and firmly bound together so closely that one branch can not develop fully without the other. Accordingly, to grasp a truthful and comprehensive notion, the industrial and scientific growth in agriculture should be measured only through all branches of science concerned, all practises involved, and the various industries included. It is this sort of concept of science in agriculture I ask you, in my closing sentence, to seek; and not simply a view which results from a study of a component of the whole.

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AN ANALYSIS OF THE MEDICAL GROUP IN CATTELL'S THOUSAND LEADING MEN OF SCIENCE

THE basis of the present study is the list of starred names in the 1906 and 1910 editions of Cattell's "American Men of Science" representing individuals who are engaged in teaching or research in medicine or who, though occupying other fields, are directly or indirectly advancing knowledge in the medical sciences.

The analyses, presented for the most part in tabular form, have been made with the object of determining

1. The principal field of activity of each individual.
2. The overlapping of different fields of activity.
3. Nativity.
4. Age.
5. Sex.
6. Education as represented by degrees.
7. Education as represented by institutions.
8. Post-graduate study.
9. Service in one or more institutions.
10. Present distribution with rank.
11. Lapse of time between degree and full professorship.
12. Change of field of activity.
13. The clinician's position as an investigator.

It is true that the entire number of individuals is too small to allow far-reaching conclusions to be drawn. Medicine in this country is, however, undergoing so many changes—changes which began about twenty-five years ago and will doubtless continue—that it seemed advisable to analyze, for future students of medical education and medical progress, the conditions as represented in Cattell's editions of 1906 and 1910. The trend of these changes and the influence of the development of the medical sciences can be traced even in the first edition and markedly in the second, by separating the older group of men, limited to chemistry, anatomy, physiology and pathology from the younger group representing, in addition to these, bacteriology, physiological chemistry and pharmacology. In the absence, however, of definite tables of earlier periods, it is difficult to draw comparison from the first edition, except such as are possible on the basis of age. If one had tables for, say 1890 to 1895, the period representing the beginning of the rapid development of the laboratory side of medicine in this country, the analysis of 1906 and 1910 would be of greater value. Still, it is hoped that the present study will preclude such regrets on the part of some student of medical education who wishes in 1930 to analyze the advances during the period of twenty years preceding his study.

The basis upon which Cattell selected the names for "American Men of Science," as well as his method of selecting the thousand leading men, are too well known for repetition. It must suffice to state that in the first edition are the records of 4,000 men and women and that the second edition was enlarged to include 5,536. The directory is essentially a list, with short records, of individuals working in the natural and exact sciences, and it is presented as "a fairly complete survey of the scientific activity of a country at a given period." Cattell's object in preparing the special list of a thousand leading men was to secure a group for the scientific study of the "conditions on which scientific research depends and so far as

may be to improve these conditions." One other point is of importance: although the first edition was published in 1906, the record apparently was completed before January 1, 1903,[1] and the first edition therefore refers to conditions as of the latter year. For this reason the list prepared from the first edition will hereafter be referred to as the "1903 list" and that of the second edition as the "1910 list."

To my use of Cattell's list of a thousand leading men as a basis for the selection of a medical group, there can be, I think, no objection. The group of medical names is all inclusive and represents medical men of every degree of scientific effort. Moreover, as a result of my studies of the special group of 238 names, I consider the selection well made; I have found only two names without stars, that in my opinion should have been starred and, on the other hand, only three starred that perhaps did not deserve a star.

METHODS OF SELECTING THE MEDICAL GROUP

In Cattell's "thousand men" those representing the medical sciences doubtless fall in the four groups: chemistry, 175; pathology, 60; physiology, 40; and anatomy, 20.[2] The three last groups are probably almost entirely composed of men working in the medical sciences, while of the first group relatively few are interested in medicine. In my classification which gives 179 names in the 1903 list and 59 new names in the 1910 list, I have disregarded Cattell's groupings for the reason that I desired to obtain a list representing men who are advancing a knowledge of the medical sciences without regard to their relation to medical schools. Thus embryologists, comparative anatomists, chemists and biologists, whose researches bear on medical problems or contribute to the methods of the medical sciences, have been included. The list is one of men working in the sciences bearing directly upon medicine rather than of medical men concerned with science.

[1] See second edition, pp. 531 and 538.

[2] The other divisions are: physics, 150; zoology, 150; botany, 100; geology, 100; mathematics, 80; astronomy, 50; psychology, 50; anthropology, 20.

Some of the criteria upon which the selection of names was made follow: A person engaged in teaching and research in medicine, whether or not possessing the M.D. degree is, of course, included. The possession of the M.D. degree by a person not concerned with medical teaching or research is not sufficient reason for inclusion unless this person's work has some bearing on medicine; thus a zoologist or biologist with the M.D. degree is not included unless he has been concerned with studies in neurology, embryology or comparative anatomy. On the other hand, a biologist without the degree of M.D., but contributing to the knowledge of the anatomy or embryology of mammals is always included as one concerned in advancing the knowledge of the medical sciences. Despite these rules, the decision as regards zoologists and biologists has sometimes been difficult, but has always rested on the relation of research work to medicine. A like difficulty arises in regard to chemistry, especially among the older group representing chemistry before the rise of physiological chemistry. Naturally a chemist whose life work has been the teaching of medical students is included irrespective of work in other fields; on the other hand, an individual holding a chair in general chemistry and teaching medical students only incidentally, and whose investigations have nothing to do with physiological chemistry is not included. So also are judged a few workers in industrial or agricultural chemistry; if their work has a direct bearing on normal physiology or the problems of disease, they are included; otherwise not. Thus chemists concerned with the study of metabolism in man or animals, but without medical degree or affiliation with medical schools, are included, as are also chemists whose problems are those of sanitation and public health closely related to the problems of the acute infectious diseases; on the other hand, sanitary engineers, concerned with water filters, sewage problems, etc., are not. The same holds for bacteriologists; a bacteriologist of non-medical training or affiliation, studying diseases of animals is accepted; one engaged only in the systematic study of lower plant

forms, or the diseases of plants is not. Psychology offers some difficulties. All workers in psychology may be indirectly contributing to the knowledge of normal and abnormal mental conditions, but the line has been drawn so as to include only those who use the material afforded by the insane and feeble-minded; that is, those who have entered or are closely in touch with the field of psychiatry; or, on the other hand, are responsible for the teaching of medical students. Pharmacists, pharmaceutical chemists and botanists interested in materia medica, although the group is very small, have caused some difficulty. They have been classified, in part, on the basis of the character of their researches, and in part on their medical affiliations, as either chemists or pharmacologists.

Under physiologists, plant physiologists have not been included, unless their work has a bearing on pharmacology; all, however, who work on lower animal forms and offer knowledge of importance to the understanding of mammalian physiology have been included.

In two small groups another factor enters; a few individuals have reached a position of importance, in fields distantly related to medicine, but owe their success in part, at least, to early efforts in clinical medicine or the medical sciences; on the other hand, a few men occupy fields which a few years ago had no relation to medicine but which now are of importance in the border-line problems of the medical sciences. In each group the decision has been laid upon the individual's influence upon medical teaching and research.

CLASSIFICATION

My classification of the medical group is made according to the predominant interest of the individual. In Cattell's classification all medical effort is distributed under the four important headings of anatomy, physiology, chemistry and pathology, with a possible scattering of medical effort under zoology, psychology, etc. To bring in the various distinct subdivisions of medicine and its allied sciences, and to give a true picture of the activities of the starred men of the medical or near-medical group, it has been necessary for me to classify under eleven headings (see Table I.). This has been necessary because a considerable number of individuals classified in Table I. as anatomists (including histologists and embryologists) are classified in "American Men of Science" as zoologists, biologists, etc. As, however, they are from the medical point of view, and for the purpose of this study, anatomists, they are so grouped. So also in the case of physiologists, pharmacologists and chemists, who may have interests in two or three fields, each individual is grouped in the field in which he has shown the greatest activity, despite the fact that according to this rule a professor of physiology may be classed as a physiological chemist. The same rule holds for those grouped by Cattell under bacteriology and hygiene, or under pathology and medicine, etc. Another difficulty arises in the group engaged in the practise of clinical medicine; an individual may be classed in "American Men of Science" under "Medicine, Neurology," or "Pathology, Medicine," though in each case neurology or medicine is the principal field of effort of the individual. Under such circumstances, provided the individual is actually engaged in clinical work, he is given a clinical classification. In some instances this robs the laboratory branches of one or two men, but, as a rule, it is merely a matter of transferring a name from "Medicine" to Surgery, Pediatrics or Psychiatry, as the case may be, and takes out of the group "Pathology," a number of clinicians who are pathologists only in the sense that they are diagnosticians of disease. Likewise the free use, by Cattell, of the single designation "Medicine" in the case of a surgeon or a psychiatrist, has necessitated the addition of other fields, as surgery, psychiatry, pediatrics, etc. In all this revision of classification the personal opinion of the writer, based on a knowledge of the work of the individuals concerned, is the chief factor. That this personal element may have led to occasional errors is possible; but for the purpose of distinguishing between the different types of activity, it is believed to be without essential error.

Whenever possible the analysis of the lists

of 1903 and 1910 is shown as a distinct part of one table. When, however, this would entail a large awkward table, and when there is no particular advantage to be gained, a composite table is given. Occasionally where differences are striking the two lists are presented in separate tables.

In interpreting these tables it should be borne in mind that although with each new edition Cattell prepares a new list of one thousand leading scientists, the names starred in an earlier list are still retained unless dropped by reason of death or removal to a foreign country. Thus in the 1910 edition of "American Men of Science" more than a thousand names are starred. The exact number over a thousand is the difference between the new names added and those dropped on account of death or departure from the United States. Therefore, my list of 59 names, taken from the second edition, includes names not starred in the 1906 edition and, naturally, none of the names which at that time were starred, with one exception, a person who changed from work in general biology to distinctly medical research. The losses of starred names in 1910, as compared with 1906, were six in number: by death, Wilbur Olin Atwater (physiological chemistry); James Carroll (bacteriology and pathology); Gaylord Parsons Clark (physiology), and John Bruce MacCallum (anatomy and physiology); by removal from the country, Arthur Robertson Cushny (pharmacology), and William Osler (medicine). (The name of Ira van Giesen appears in the first edition but not in the second and is not noted among deaths or removals.)

It should also be explained that although the directory includes many Canadian scientists, these are not considered by Cattell in making up the lists of 1,000 leading men.

A classification, according to principal field of activity, is shown in Table I.

Despite the attention given to classification, as described above, certain liberties have been taken with this table; under pathology (comparative) has been included an individual classified by Cattell as a medical zoologist; under bacteriology are included three individuals whose chief work is in hygiene; and under pharmacology are included two men who are essentially medical botanists. These inclusions are made here for the sake of shortening the table; in later tables, however, due allowance has been made so that statistics concerning pharmacologists, for example, are not confused by including botanists. It should also be stated that under neurologists are included only men working in clinical neurology or neuropathology. Neurologists, in the sense of anatomists studying the anatomy of the nervous system, and not in clinical work, are included under anatomists.

TABLE I

Classification According to Principal Field of Effort

Field	1903 List Number		1910 List Number
Anatomy	45	Including histology, embryology and comparative anatomy	12
Physiology	31	Including comparative physiology	11
Pathology	21	Including comparative and experimental pathology	6
Bacteriology	15	Including protozoology and hygiene	7
Chemistry	29	Inorganic, organic, physiological pharmaceutical and micro-chemistry and toxicology	9
Pharmacology	7	Including materia medica, therapeutics and medical botany	4
Medicine	20	Refers to internal medicine	2
Psychiatry	3	Including psychology	3
Neurology	3		2
Surgery	2		3
Pediatrics	3		0
	179		59

Total of both lists, 238.

The chief points of interest brought out by this table are: (1) the large number of individuals in the older laboratory sciences—anatomy, physiology and chemistry—as compared with the number in those, pathology, bacteriology and pharmacology, of more recent development, and (2) the relatively small number of clinicians who have attained scientific distinction. These differences hold in both lists.

TABLE II

Laboratory Group, Showing Overlapping of Fields of Activity

	1903 List	1910 List
Anatomy and zoology	9	1
Anatomy and biology	5	2
Anatomy and physiology	5	0
Anatomy and neurology[3]	3	0
Anatomy, neurology[3] and biology	1	0
Anatomy, biology and physiology	2	0
Anatomy, biology, zoology, neurology[3] and physiology	4	0
Anatomy, anthropology and neurology[3].	1	0
Anatomy, biology and zoology	2	0
Anatomy, pathology and bacteriology	2	0
Physiology and hygiene	1	0
Physiology and history of medicine	1	0
Physiology and psychology	2	0
Physiology and biology	3	1
Physiology and neurology[3]	1	0
Physiology and pharmacology	4	1
Physiology and physiological chemistry.	8	0
Physiology and pharmacology and physiological chemistry	2	2
Pharmacology and physiological chemistry	2	2
Pathology and physiological chemistry.	0	2
Pathology and bacteriology	13	4
Pathology and bacteriology and hygiene	2	0
Pathology, physiology and experimental surgery	0	1
Bacteriology and hygiene	4	4
Bacteriology and biology	1	0
Bacteriology and zoology	1	0
Bacteriology, hygiene, biology and physiological chemistry	2	0
Bacteriology, hygiene and physiological chemistry	1	1
Chemistry and hygiene	1	0
Chemistry and toxicology	3	0
Chemistry and pharmacy	2	1
Chemistry and hygiene	2	0
Chemistry and physics	1	0
Botany, pharmacy and materia medica.	2	0
	93	22

In connection with the clinical branches, the striking fact is shown that in the 1903 list more men have gained scientific distinction in internal medicine than in all the other fields of clinical effort combined. On the other hand, in the 1910 list, the distribution is more even. The preponderance of internists in the earlier list is due, as will be shown later, to the large number of teachers of medicine, who before the period of laboratory expansion combined with their teaching, investigations in pathology, pharmacology, hygiene, etc.

TABLE III

Clinical Group—Variety of Interests

	1903 List	1910 List
Medicine and anatomy	1	0
Surgery, anatomy, physiology and materia medica	1	0
Medicine and physiology	1	0
Surgery, neurology[4] and physiology	1	0
Surgery and physiology	0	1
Neurology and physiology	1	0
Medicine, pathology, pharmacology and physiological chemistry	1	0
Medicine, pathology and therapeutics	0	1
Medicine, pathology and physiology	1	0
Medicine, neurology, physiology and toxicology	1	0
Medicine, neurology and psychiatry	0	1
Medicine, pharmacy and materia medica.	1	0
Medicine and physiology	1	0
Medicine and pathology	6	1
Medicine and hygiene	0	1
Medicine, pathology and bacteriology.	2	0
Medicine, pathology, bacteriology and hygiene	1	0
Medicine, pathology and physiological chemistry	1	0
Medicine and physiological chemistry	0	1
Obstetrics, pathology and bacteriology.	1	0
Neurology, psychiatry and pathology	1	1
Medicine, bacteriology, hygiene and bibliography	1	0
Botany, physiology, materia medica, pharmacology, medicine and neurology.	1	0
Psychiatry and hospital organization	1	0
	25	7

Although Table I. shows the general distribution by important groups, it does not give a complete picture of the variety of effort represented by some of the members of these

[3] Refers here to anatomy or physiology of the nervous system; not to clinical neurology.

[4] In this table neurology refers to clinical neurology.

groups. In Tables II. and III. this variety of effort is shown. Incidental effort in a neighboring field is not indicated, only more serious effort in teaching or research. Table II. represents laboratory effort only, while Table III. shows the activities of those persons engaged in the several fields of clinical medicine.

Thus it is seen that of the 179 individuals in the 1903 list 118 or 65 per cent. were interested in more than one field of activity; while in the 1910 list only 49 per cent. were working in more than one field. These figures would appear to indicate, among the latter group, a tendency to specialize.

NATIVITY

Table IV.[5] shows distribution according to birth. For the purpose of condensing the table no state is given alone unless it is represented by more than two names; states with one or two names are grouped under the words "other states" appearing in each division. For the sake of record these may be given as follows: Vermont 1 (1903); New Hampshire 1 (1910); District of Columbia 1 (1903); North and South Carolina each 2 in 1903; Tennessee 2, Alabama and Mississippi each 1 in 1910; Minnesota 1, in 1903; Colorado and California each 1 in 1903, and California 1 in 1910.

If this table is contrasted with a similar table by Cattell in which is analyzed the larger group of one thousand scientists, the following points of similarity or difference appear:

1. Of the larger group (1,000) 126 were foreign born; of the medical group (238), 37; 12.6 per cent. as compared to 15.5 per cent. Of the 37 foreign born, 14 were natives of Canada, and if these are set in a separate group, the members of the medical group of non-American birth are but 9.6 per cent. Another point is of interest in this connection: In our 1903 list, 13 medical men are shown to be of Canadian birth, while Cattell's corresponding list shows for the entire 1,000, a total of 34 of Canadian birth. This shows that more than one third of the individuals of Canadian birth have achieved their prominence through the medical sciences. As far as any one influence is concerned in this it would appear to be connected with the University of Toronto. Of the 13 individuals of the medical group, resident in the United States in 1903, eight were graduates in arts or medicine of this university. No other Canadian institution is represented by more than one individual. On the other hand, as five of the Canadians went to Hopkins for post-graduate study, this institution would appear to be a secondary important factor in that it drew the

TABLE IV

Nativity: Born in United States, 200. Foreign Born 37[6]

	North Atlantic Division							South Atlantic Division			South Central Division		North Central Division								Western Division	Foreign Born								
Lists	Maine	Massachusetts	Connecticut	New York	New Jersey	Pennsylvania	Other States	Maryland	Virginia	Other States	Kentucky	Other States	Ohio	Indiana	Illinois	Michigan	Wisconsin	Iowa	Missouri	Other States	All States	Canada	British Isles	Germany, Austria	Sweden	Switzerland	Russia	India	Japan
1903	5	22	9	31	5	17	1	9	5	5	3	0	10	4	5	5	8	3	1	1	2	13	6	5	0	1	2	1	0
1910	1	6	1	9	2	2	1	1	3	0	2	4	5	3	1	1	1	1	4	0	1	1	2	2	2	0	1	0	1
Totals	6	28	10	40	7	19	2	10	8	5	5	4	15	7	6	6	9	4	5	1	3	14	8	7	2		3	1	1

[5] In this and all other tables in which totals do not agree with those of Table I., it is to be understood that the records, as given in "American Men of Science," were, in some instances, incomplete or difficult of interpretation.

[6] Birth place of one individual in 1903 list not given.

men from Canada. Only two other institutions, Clark and Chicago, attracted two men each. This Canadian influence is lost, however, in the 1910 group, which contains only one individual born in Canada.

In connection with the group of 37 foreign born, it is of interest that nearly one half received part or all of their education in the United States, thus five received the Ph.D., eight the M.D., and four the bachelor, and later degrees from American schools. On the other hand, twenty appear to have finished their professional education in other countries. On the basis of this analysis it would appear, therefore, that only 8.4 per cent. of the entire medical group of 238 individuals represents entirely foreign educational influences.

It is of interest that the distribution by birth in this country of the medical group is in general in proportion to Cattell's figures for the larger group of one thousand men of science. This is shown in the following table in which only those states are given which have 20 or more men in the 1,000 list.

TABLE V

Nativity: Comparison of 1,000 with Medical Group

	N. Y.	Mass.	Ohio	Penna.	Ill.	Conn.	Wis.	Maine	N. J.	Ind.	Mich.	Md.	Iowa
Cattell's 1,000.	183	134	75	66	42	40	35	29	28	28	27	26	20
Medical 238...	40	28	15	19	6	10	9	6	7	7	6	10	4

AGE

Table VI. gives the age by decades of the individuals composing the various subdivisions of the medical group, as prepared from the 1903 list. To this is added the analysis, by age only, of members of the 1910 group. This table presents several points of interest. In each list the decade represented by the largest number of individuals is the fourth; in the 1910 list, the majority of all names falls in this decade, while in the 1903 list it is shared by the fourth and the fifth decades. As, however, we have no lists before 1903, for comparison it is impossible to say how many of the men in the fifth decade, in 1903, might have been starred in a list prepared in 1893, when they were between 30 and 40. All evidence points to the fourth decade as the period when the majority of men in the medical sciences reach an unusual degree of prominence. From the 1910 list it is certain that the chance for prominence diminishes rapidly after the 40th year. This may not be true in clinical medicine, for, as shown in the 1903 list, the largest number appear in the fifth and seventh decades. The various laboratory specialties show little difference except in the case of anatomy and pathology, each of which has an unusual proportion of individuals reaching prominence in the fourth decade. In these two branches half the total number in each group fall in the fourth decade. The probable explanation lies in the changes in medical education which began in the early nineties. Until that time pathology was in most schools taught by a clinician and the teaching of anatomy was frequently relegated to a surgeon. The divorcing of anatomy and pathology from medicine and surgery and the increase of laboratory teaching in these two subjects opened many opportunities for scientific work, previously closed. These changes, in all probability, explain the large number of prominent men in these two fields who in 1903 fell in the fourth decade.

TABLE VI

Age

1903 List	20–30	30–40	40–50	50–60	60–70	70–80	Age Not Given
Anatomy...............	3	22	13	5	2		
Physiology.............	4	10	11	5	1		
Chemistry..............		10	9	7	2	1	
Pathology..............	1	10	7	2			1
Bacteriology and hygiene .	1	4	6	1	2		1
Pharmacology, therapeutics..................		2	5				
Medicine...............		4	6	3	6	1	
Surgery, neurology, psychiatry, pediatrics......		3	2	3	2	1	
Totals.................	9	65	59	26	15	3	2
1910 list—totals.........	1	34	14	9	1	0	
Combined totals.........	10	99	73	35	16	3	2

SEX

In the 1903 list of 179 names, 4 women find a place, three representing anatomy and one

hygiene; in the 1910 list, three are added, two representing anatomy and one bacteriology and chemistry; a total of 7 or almost 3 per cent. of the combined lists.

EDUCATION AS REPRESENTED BY DEGREES

In connection with Table VII., which presents the educational qualifications of the members of the medical group, as shown by their degrees, a few words of explanation are necessary. Honorary degrees are not included. M.B. is given the same value as M.D. The omissions tabulated under "insufficient data" refer to an anatomist who is described merely as a "licentiate," one chemist with the single degree of E.M.; and to a third individual whose record gives no information concerning degrees. Otherwise degrees are accurately given, except that the chemist with bachelor's degree only should be credited also with a degree in pharmacy (Ph.G.). In the column headed "M.D. only" the figures in brackets refer to the number in this class who took some academic work but did not receive the bachelor's degree.

The figures for the 1910 list are given at the bottom of the table without division into scientific groups.

The figures presented in Table VII. bring out some interesting facts. The most striking of these is the small number of men in the 1910 list with the degree M.D. only, 8.5 per cent. as compared with 24.5 per cent. in the 1903 list. That this is not due to a larger number of men with the Ph.D. degree only, is shown by the fact that in the two lists the percentage of individuals[7] with the latter degree only, is practically the same, 26.2 per cent. for 1903 and 25.4 per cent. for 1910. On the other hand, the number of individuals with M.D. degree equals 68 per cent. in the 1903 lists and 71 per cent. in the 1910 list, again practically no change. The conclusion is unavoidable that about two thirds of the prominent men in each list were developed through the training represented by the M.D. degree and about one quarter through that represented by the Ph.D. degree, but that in the period represented by the 1910 list, there was a greater tendency on the part of the M.D. group to anticipate the present educational prerequisite in medicine—a collegiate education. In the 1903 list individuals with the bachelor's or master's degree antedating their M.D. degree constitute only 34 per cent. of the total; in 1910 this percentage increased to 51. On the other hand, it is worthy of note that in the entire list of 238 individuals only 9 achieved distinction on the basis of the bachelor's or master's degree or the degree Sc.D.

TABLE VII

Education as Represented by Degrees—238 individuals

1903 List	Bachelor's and M.D.	Master's and M.D.	Bachelor's Sc.D. and M.D.	Ph.D. and M.D.	M.D. Only	Bachelor's Only	Bachelor's and Master's	Bachelor's and Sc.D.	Ph.D.	Bachelor's Sc.D and D.V.M.	Sc.D. and M.D.	Insufficient Data	Totals
Anatomy	9	6	1	1	10 (3)	1	1	1	14			1	45
Physiology	4	6		3	6 (3)				11	1			31
Chemistry	2	1		3	2	1	1	1	15		1	1	29
Pathology	7	4		2	7 (5)				1			1	21
Bacteriology and hygiene	1		1	1	6 (2)		1		5				15
Pharmacology	2	1		2	2 (1)								7
Medicine	8	2		1	9 (1)								20
Surgery, neurology, psychiatry, pediatrics	4	4			2 (2)				1				11
Totals	37	24	2	13	44 (17)	2	3	2	47	1	1	3	179
1910 list	19	11	1	6	5	1	0	1	15	0	0	0	59
Combined totals	56	35	3	19	49	3	3	3	62	1	1	3	238

[7] In this calculation individuals with both M.D. and Ph.D. degrees (13 in 1903 and 6 in 1910) are classed in the M.D. group, as is also one individual with ScD. and D.V.M. degrees.

With the exception of the Ph.D. degree, the various degrees are distributed about equally among the several medical sciences. Anatomy, physiology and chemistry, the older and more exact of the group, claim, as would be expected, nearly all the Ph.D. men.

EDUCATION AS REPRESENTED BY INSTITUTIONS

In Table VIII. is presented the group of institutions which have given five or more degrees to individuals in 1903 and 1910 lists. In this table degrees are tabulated, not individuals, that is, a man receiving the degrees A.B., A.M. and M.D. is tabulated three times; if, in addition, he received a Ph.D. degree, he receives four places.[8] The object of the table is to show in a general way the institutions concerned in training the larger number of the group. To limit the tabulation to institutions granting five or more degrees is not entirely satisfactory, but the list of institutions

TABLE VIII

Institutions Represented by Five or More Degrees; 1903 and 1910 Lists Combined

	A.B.	B.S.	Ph.B.	A.M.	M.S.	Sc.D.	Ph.D.	M.D.[9]	D.V.M.	E.M.	Ph.G.	Totals
Harvard	22	7		15		3	5	24				76
Johns Hopkins	13	1			1		18	14				47
Columbia	4		2	4			7	18		1		36
Yale	8	5	3				8	3				27
Pennsylvania	4	2	1				2	18				27
Michigan		5	1	1	3	1	2	8				21
Chicago (including Rush Med. School)		2			1		13	5				21
Cornell	1	3	3	1		1	1		1			11
Toronto	7			1				2				10
Princeton	4			4								8
New York University and Bellevue								6				6
Leipzig							4	2				6
Wisconsin		3			1						1	5
Missouri		2						3				5
Northwestern		1			1			3				5
Amherst	4			1								5

credited with four, three, two and one degree is so lengthy that tabulation is impossible. Thus three institutions are credited with four degrees; six with three; seventeen with two and one hundred and sixteen with one. The tabulation of these in detail serves no good purpose. If we compare Table VIII. with Table VII. we find in regard to the M.D. degree that 106 of the 163 medical degrees were given by 12 institutions; the remaining 57 being scattered among 35 institutions. Also 60 of the 81 Ph.D. degrees were granted by 9 institutions; the remainder representing 13 institutions. 21[10] of the M.D. and 15 of the Ph.D. degrees were granted by foreign universities. Foreign universities giving more than one M.D. degree are Toronto, Strassburg, Bonn, Leipzig, Aberdeen and Edinburgh. The only foreign universities which find a place in the table are Toronto and Leipzig.

Some objection might be raised to the insertion in this table of Amherst and Princeton, which do not have medical departments. However, the table is intended to represent general educational preparation and brings out prominently the important rôle played by Harvard, Hopkins, Columbia, Yale, Pennsylvania, Michigan and Chicago—the universities represented by more than twenty degrees—in the development of the medical sciences.

One or two minor points noted in the preparation of this table are:

1. The women's colleges represented are Smith, Radcliffe, Vassar and Bryn Mawr.

2. The figures for Toronto, Amherst and Northwestern are based on the 1903 list; no new names occurred in the 1910 list.

3. Homeopathic schools are represented by two individuals, one working in botany and materia medica and the other in anatomy and anthropology.

One purpose in preparing Table VIII. was to determine how many men took all their work in one university and whether workers in any one scientific group favored certain universities. The analysis on this point yields the following information: Of 62 individuals with the Ph.D. degree (in 1903 and 1910 lists) 24 took all work leading to this degree in one institution, as follows; Johns Hopkins: anato-

[8] There is in this table a slight error due to the fact that Ph.D. men do not always give data concerning the bachelor and master's degree.

[9] Including M.B.

[10] Of these 5 were conferred by Canadian; 4 by English, and 12 by German schools.

mists, 2; physiologists, 4; physiological chemists, 2; pharmacologist, 1; Columbia: physiologist, 1; physiological chemist, 1; psychologist, 1; Yale: physiological chemists, 4; physiologists, 2; Harvard: pharmacologist, 1; psychologist, 1; Cornell: physiological chemist, 1; Chicago: physiologist, 1; George Washington University: anatomist, 1; and Pennsylvania: chemist and bacteriologist, 1.

A similar study of men (1903 and 1910 lists combined) with the medical degree shows that of 80 receiving their bachelor degree in a university with a medical department, 40 remained for their medical education while an equal number went elsewhere. Of the first group Harvard claims 16, Pennsylvania 5, Michigan 4, and John Hopkins, Yale and Edinburgh, each 2.

POST-GRADUATE STUDY

As a supplement to Table VIII. is presented an analysis (see Table IX.) of post-graduate study after the winning of the M.D. or Ph.D. degree or in the absence of these, the bachelor's or master's degree. As post-graduate work is included (1) work as a fellow, (2) residence in a teaching or research institution with or without appointment and (3) foreign study. Also where an individual holds both the M.D. and Ph.D. degrees work for the later of these is counted as post-graduate work. When an individual has not held a fellowship and no special course of study is given, the first appointment (as assistant, instructor, lecturer, etc.) after graduation is considered as post-graduate work. Some objection might be raised to including the first appointment as post-graduate study, but as it frequently offers the best criterion of conditions determining future work and of crystallizing the tendencies of the individual, it seems justifiable. On the other hand, if this first position was presumably devoid of opportunities for training, as, for example, a position in a secondary school, it has not been included. In this table, unlike the others, in order to bring out general tendencies, the compiler has freely used his discretion as to omissions at the expense, perhaps, of some of the smaller institutions. Despite all these liberties, the table has been prepared with great difficulty. This has been due in part to the complete absence of all data in connection with some names, and in part to the difficulty of defining graduate work, that is, determining what should and what should not be included. One other difficulty must be mentioned. Although the majority of individuals are credited with postgraduate work in only one or two institutions, some studied in four or more. As a result, in Table IX. the latter have been counted four or more times; thus the same individual may be credited to Columbia, Hopkins, Germany and France, though the total time spent in these four places may not have been greater than that given by another individual credited only to Columbia. To indicate the time element, an attempt was made early in the compilation to indicate length of time of post-graduate study, but this was beset with so many difficulties that it was abandoned. The table, therefore, indicates diversity of post-graduate study by a number of individuals, without regard to the time element, or the sequence of study. For convenience of tabulation foreign universities are grouped under the name of the country in which they are located. So also work in federal, state and city laboratories and in the army and navy are grouped under the head of *Government Work*.

TABLE IX

Post-graduate Instruction; 1903 List Only

	Anat.	Phys.	Chem.	Path.	Bact. and Hyg.	Pharm. and Therap.	Clin. Med.	Surgery, Neurology, Psychiatry, Pediatrics	Totals
Hopkins	13	10	2	8	6	2	3	1	45
Harvard	7	7	1	2	1		2	3	23
Columbia	5	4	2	3	1		1	1	17
Government work	2	1	2	4	4		1		14
Pennsylvania	3	1		1	1	1	5		12
Michigan	5	1		1	2	1			10
Chicago	4	2				1		1	8
Clark	4	1			2				7
Yale		1	4		1				6
Cornell	1	1	1			1			4
Germany	11	13	14	12	5	4	7	1	67
France	1	1	2	2	4		1	2	13
England	1	5	2	1			1	1	11
Austria	1			2	2		1	2	8
Scotland	1	3						1	5
Italy	2	1			1				4

In this table, based on the 1903 list only, institutions or countries credited with less than four post-graduates are not given. The 1910 list, because of the small number of names, can not be conveniently given in tabular form. It shows however that institutions represented by more than one post-graduate are as follows: Harvard, 11; Government Work, 8; Johns Hopkins, 6; Yale and Pennsylvania, each 4; Chicago and Cornell, each 3; and Columbia, 2. Foreign countries are represented as follows: Germany, 13; Great Britain, 5; Austria, 3; France and Canada, each 2.

These figures from the 1903 list indicate clearly the prominent part which Johns Hopkins University has played in stimulating the development of the medical sciences in this country and also the predominant influence of Germany upon American medicine. Germany's lead holds in both lists, but Hopkins and Harvard change places in the 1910 list, while Yale improves its standing at the expense of Columbia, and Michigan and Clark drop out of the list. Just how important these changes are, it is impossible to say on account of the smaller number of names in the 1910 list as compared with that of 1903.

CONSIDERATIONS OF PROFESSIONAL ADVANCEMENT

In preceding tables (VII., VIII. and IX.) have been presented academic and professional education and post-graduate work up to or including the first appointment held. It is now of interest to consider the progress of these various individuals in their later professional life. To this end are presented (*a*) the number of individuals remaining continuously in one, working in two only, or in three or more institutions; (*b*) residence and position of individuals in both groups at the time (1903 and 1910) of Cattell's classifications; (*c*) the length of time between receipt of last degree and appointment as full professor; and (*d*) changes in field of work.

Table X. presents those institutions in which two or more men have labored continuously from time of first appointment. In preparing this table, which includes both 1903 and 1910 lists, scholarships and fellowships have not been considered (these are included in Table IX). Likewise, incidental teaching, research or administrative positions held simultaneously in other institutions, usually of the same city, have also been disregarded.

TABLE X

Continuous Residence in One Institution—85 Names from 1903 and 1910 Lists

	Anatomy	Physiology	Chemistry	Pathology	Bacteriology and Hygiene	Clinical[11]
Cornell	1		1			
Michigan	2			1	2	
Columbia	3	1		1	1	1
Pennsylvania	3	1	1		1	6
Johns Hopkins	2	2		1	1	2
Harvard	2	4[12]		4	1	6
Government	1	1	1	1	3	
Chicago (including Rush Med. College)				3		
Yale		1	3			
Wisconsin	1		1		1	
Western Reserve		1[12]	1	2		
Buffalo				1		1
Bellevue						2
Missouri	2					

In addition to the data presented in the table, the following institutions are to be credited with one man each: Anatomy: Minnesota, Princeton, Smith, Washington and Iowa; physiology: Syracuse, Nebraska, Medico-Chirurgical College and the Rockefeller Institute; bacteriology and hygiene: Wesleyan and Massachusetts Institute of Technology; clinical medicine: Albany Medical College.

In Table XI. is shown the number of men who have worked in only two institutions.

Institutions having one individual in first column only are Toronto, Smith, Edinburgh, Clark, Dartmouth, Virginia, Manitoba, Haverford, St. Louis Medical College, Miami, Georgetown, and Massachusetts, New York and Cincinnati Colleges of Pharmacy; in second column only, Bowdoin, Texas, Minnesota, Western Reserve, Buffalo, Jefferson, Vanderbilt and Simmons.

[11] Medicine, surgery, neurology, psychiatry, pediatrics.

[12] Including one pharmacologist.

TABLE XI

Service in Two Institutions Only—56 Names—from 1903 and 1910 Lists

	First Position	Second Position
Hopkins	10	5
Michigan	4	1
Chicago (including Rush Medical College)	1	5
Columbia	5	6
University and Bellevue	4	4
Missouri	0	2
Cornell	0	5
Harvard	2	5
Rockefeller Institute	0	2
Yale	3	0
Government work	4	2
New York Polyclinic	2	0
Wisconsin	0	4
Albany Medical College	1	1
California	1	2
Wesleyan	1	1
Northwestern	1	2
Pennsylvania	2	2
Bryn Mawr	2	0
Stanford	2	0
Massachusetts Institute of Technology	0	2

A comparison of Tables X. and XI. shows that of the total of 238 individuals, definite scientific prominence was attained by 85 who remained in one institution and by 56 who had worked in two institutions; of the remaining 97, about three quarters are definitely credited with residence in three or more institutions.[13] On the basis of such a classification it would appear that greater opportunity for successful effort, and therefore greater scientific prominence, attends continuous residence in one institution. On the other hand, if the second and third group are added together, the figures favor migration. The first group, which includes a large proportion of the older men in anatomy, physiology, chemistry and the clinical subjects, is in striking contrast to the condition under the German system; on the other hand, the second and third groups contain a large number of the younger men representing prominence in pathology, bacteriology, hygiene and physiological chemistry, and is suggestive of the principle of migration so characteristic of the German system. Another important point brought out is that a relatively small number of institutions have fostered this selected group, or at least have given them opportunity for attaining prominence. This is shown in Table XII., which is based upon the total number of positions held by 158[14] individuals of the 1903 list only. Only institutions represented by four or more positions are given.

TABLE XII

Institutions and Positions Represented by 158 Individuals of 1903 List.

Institutions	Position					Totals
	Permanent	I.	II.	III.	IV. or Later	
Johns Hopkins	7	19	6	5	3	40
Harvard	12	7	5	1	–	25
Columbia	6	8	7	3	–	24
Michigan	5	6	4	4	1	20
Pennsylvania	10	4	4	–	1	19
Chicago	1	1	8	7	1	18
University and Bellevue	2	4	6	–	–	12
Northwestern	–	1	4	1	1	7
Cornell	2	2	3	–	–	7
Yale	2	3	1	–	–	6
Western Reserve	3	–	3	–	–	6
Missouri	1	–	3	–	1	5
California	–	1	2	1	1	5
Clark	–	1	3	1	–	5
Minnesota	1	–	1	2	–	4
Rockefeller Institute	1	–	2	1	–	4
Foreign Universities	–	7	1	1	1	10
Federal, State, City and Hospital	6	3	2	6	5	22
Grand total						239[15]

Table XII. shows 239 positions divided in 18 ways. If foreign universities, federal, state and city and hospital positions and the Rockefeller Institute are removed, we have 203 positions divided among only 15 universities. As the total number of positions occupied by the 158 individuals was 314 it is evident that

[13] The data concerning twenty-one is either incomplete or too indefinite for tabulation in this regard.

[14] Twenty-one names are omitted because of unsatisfactory or indefinite data.

[15] Institutions represented by less than 4 men total 75 positions, making a final total of 314 positions.

these fifteen universities were responsible for two thirds of the opportunities offered for advancement in the sciences of medicine in this country up to the year 1903. The institutions offering more than ten positions are seven in number, Hopkins, Harvard, Columbia, Michigan, Pennsylvania, Chicago and New York University,[16] in the order named, with a total of 158 positions or almost exactly half of the positions (314) represented by the total number of individuals.

PRESENT DISTRIBUTION WITH RANK

Table XIII. presents the distribution of the entire 238 individuals and their rank as given in the 1906 and 1910 editions of "American Men of Science." Persons characterized as "emeritus" or "retired" are credited according to their last appointment. Nine men in active service in 1906 are not included in the table; these represent two men called to foreign universities, a medical clinician, a specialist in tuberculosis—the last two without university affiliation—a librarian, and four men whose later records are incomplete. The table thus really includes only 229 individuals.[17]

TABLE XIII

Distribution and Rank; 1903 and 1910 Lists; 229 Names

	Professor	Adj. or Associate Professor	Assistant or Junior Professor	Instructor, Lecturer, Associate or Assistant	Director, Chief or Curator	Emeritus or Retired	Totals	Gains in 1910
Harvard	15	3	3	4			25	8
Hopkins	9	8		1			18	3
Columbia	10	3		3		2	18	4
Pennsylvania	12			1	3		16	5
Chicago (incl. Rush)	5	6	2	1			14	4
Cornell	9	1	2		1		13	4
Federal and state depts.					11		11	4
Michigan	8			1			9	1
Wisconsin	5			2			7	3
California	2		2	2			6	0
N. Y. University and Bellevue	5					1	6	1
Rockefeller Institute					6		6	2
U. S. Army and Navy and P. H. Service	1				2	2	5	1
Western Reserve	4					1	5	3
Minnesota	2		1	1			4	0
Northwestern	3	1					4	0
Missouri	2	1	1				4	1
Yale	2		2				4	2
Hospitals					4		4	2
Wesleyan	2	1					3	0
Illinois	3						3	1
Mass. Institute of Technology	1			2			3	1
St. Louis Medical School	1				1		2	0
Buffalo	2						2	0
Philippine Med. School	2						2	2
Stanford	2						2	1
Indiana	1	1					2	1
Other Institutions	24	3	1	1	2	1	31	5
Not classified							9	0
Totals							238	59

It is of interest also that this very definite support of scientific medicine concerns almost entirely the university schools; independent medical schools play little or no part in this table.

16 Including the old New York University and Bellevue Hospital Medical Schools.

17 Only institutions represented by two or more places are given in the table. Other institutions represented by one professor are: Bowdoin, Texas,

In Table XIV., based on the 1903 list only, is shown the lapse of time, in the several broad groups representing medicine, between the receipt of last degree and attainment of full professorship, and also the number in each group who have reached prominence without the grade of full professor. The number of individuals in this table is only about two thirds (140) of the total number (179) studied. The names omitted represent those who do not fall readily into the groups given, who are without academic affiliation, or whose records are incomplete. Those who taught two subjects, as anatomy and physiology, and those who held two chairs in succession, as, for example, a clinician, temporarily the occupant of a chair of pathology, are classified more or less arbitrarily according to their greater prominence in one or the other of the subjects named, but each is counted only once.

TABLE XIV

Lapse of Time between Degree and Full Professorship. 1903 List, 140 Names

	Totals	1–2 Years	3–5 Years	6–10 Years	11–20 Years	20–27 Years	Average No. of Yrs.	Lower Grades
Anatomy	41	7	4	9	4	2	8	15
Physiology	27	1	4	6	5	1	9	10
Physiol. chem. and pharmacology	19	5	5	6	0	0	4	3
Pathology, bacteriology and hygiene	30	1	7	8	6	1	8½	7
Clinical	23	0	0	8	6	6	14½	3
Totals	140	14	20	37	21	10		38

It is seen that in anatomy, physiology, pathology and bacteriology the average wait is about the same, eight to nine years; in physiological chemistry and pharmacology it is low—four years—all full professors in these subjects having been appointed within ten years of their graduation; in clinical medicine the average is nearly double that of the other branches. The early average in physiological chemistry and pharmacology is, in all probability, due to the rapid development of these subjects as a part of the curriculum of the modern medical school; the high average in medicine is doubtless to be explained by the old custom of appointing only prominent consultants to chairs of medicine. An analysis of the appointments in anatomy indicates that the large number of early appointments is to be explained by the comparatively recent policy of divorcing the teaching of anatomy from that of physiology and surgery, which has thrown open many chairs to the younger men specializing in anatomy. Only in the clinical branches apparently has there been, in the past, much chance for a man to be called to a chair after twenty years. Considering all branches the largest number of individuals reached professorial rank during the second five-year period after graduation.

The individuals who have attained prominence without becoming full professors present great variation in lapse of time after graduation; in anatomy the extremes are one and twenty-five; in physiology, two and thirteen; in physiological chemistry, two and ten; in pathology and allied subjects, one and eleven; in clinical medicine, nine and twelve. It is noteworthy, however, that of the entire group of thirty-eight individuals representing grades lower than professor, only six had been graduated more than ten years.

Clark, Iowa, Princeton, Knox, Smith, Syracuse, Tufts, Medico-Chirurgical of Philadelphia, Vanderbilt, Woman's Medical College of Philadelphia, Chicago Homeopathic Medical College, Eclectic Medical Institute of Cincinnati, Virginia, Pittsburg, Ohio, Washington and Lee, Washington University, George Washington University, the Jefferson, Denver and Albany Medical Schools and New York College of Pharmacy; by lower grades of title, Simmons, Dartmouth, Bryn Mawr, Nebraska and Georgetown; by a director, Pennsylvania State College and a commercial laboratory.

CHANGE OF FIELD OF WORK

That success or prominence in a given field is necessarily the result of continuous single-minded effort in that field is supported by an analysis of the 1903 list. Excluding concurrent appointments, the interacting interests of the group representing physiology, physiological chemistry and pharmacology and the very natural communion of interests shared by pathologist and clinician, there is very little tendency to change in field of effort. Two

anatomists had an early brief experience in pathology and one in physiology. Three physiologists started as anatomists, but changed their interest early in their career. Some of the physiologists and chemists entered the field of pharmacology, and some of the latter that of pharmacy also, but in no instance have they been interested in other branches.

Three pathologists had initial appointments in anatomy or histology, and one in clinical medicine. One bacteriologist had an early appointment in chemistry.

THE CLINICIAN AS AN INVESTIGATOR

Of the clinical group, five individuals had been professors of pathology, while two had held chairs of materia medica, one a chair of botany and therapeutics and one a chair of anatomy. Three others had been, respectively, professor of hygiene, physiology and the institutes of medicine. Of those who had not held chairs, three had done notable work in pathology, one in physiology and toxicology and one in clinical hematology (microscopy). These activities are naturally those closely related to diagnosis and treatment, respectively, and it is probably these activities in the science of medicine, and not the actual practise of medicine, which gave the individuals in question their prominence as men of science. The history of medicine in this country shows that the first medical laboratories, presided over by men who did not practise medicine, were those of chemistry. Anatomy and physiology, at first in the hands of the clinicians, were the subjects next to acquire laboratory facilities and full-time men. Still later, pathology was divorced from clinical teaching and became a laboratory subject. But until about twenty to twenty-five years ago, the advancement of the medical sciences, aside from chemistry, was largely in the hands of clinicians, and it was men of the type represented in this list—as Mitchell, Delafield, Fitz and Janeway—who kept the scientific side of medicine alive in the period preceding the development of our present manifold laboratory activities. That twenty men in internal medicine and thirteen men in surgery and the specialties—men busily engaged in the actual practise of medicine—should constitute almost one fifth of a list of 179 prominent medical men of science, the majority of whom are laboratory men, is a matter for sincere congratulation. It will be interesting to see whether or not the new conditions in medicine, the full-time chairs in clinical medicine and the better equipped clinical and research laboratories, yield as large a number of prominent scientists in clinical medicine. The 1910 list with its 59 new names is too small and too near the 1903 period to be of value. It shows only two new names in internal medicine, three in psychiatry, two in neurology, three in surgery and none in pediatrics, as contrasted with twenty, three, three, two and three in 1903. For psychiatry, neurology and surgery this is an excellent showing; for internal medicine and pediatrics, opinion must be deferred.

Richard M. Pearce
University of Pennsylvania

THE NATIONAL FORESTS

The first-hand impressions and experiences gained on his thirty-day tour of the National Forests are described as "invaluable" by Secretary of Agriculture Houston in a letter which he sent on his return to Washington to the chief forester, expressing his approval of the administrative work and methods of the forest service.

Starting out with the expressed intention of seeing the work with his own eyes and studying on the ground the principal problems involved in managing and developing the forest resources of the country, Secretary Houston visited typical forests in each of the six great forest districts of the west, penetrating into the wilds on logging locomotives, automobiles, horseback, and at times on foot, and getting into personal touch, not only with the rangers and guards, but with homesteaders, cattlemen, lumberjacks and others among whom the forest officers do their work. Secretary Houston in his letter to the forester says:

I especially desired to familarize myself with the administrative machinery and business methods, to acquaint myself with the grazing condi-

tions, the water-power developments, the timber operations, the relation of the forests to agriculture, the road and trail and other improvements, the recreational use of the forests, other uses, and to see some of the typical homestead claims. I was afforded an opportunity to see typical forests in each of the districts and some of the more striking operations of each of them.

I regret that it was physically impossible for me to visit more of the forests in each district. I feel, however, that I accomplished my main purposes and that the results of my trip are invaluable. I was exceedingly gratified with the evidence of enthusiasm, loyalty and devotion to duty on the part of all representatives of the department with whom I came in contact. I was especially impressed with the intelligent and sympathetic attitude between the forest service and the users of the forests and of all communities dependent upon them. It was pleasing to observe that in the forests themselves the residents and other users look to the forest officers, not only for information bearing on forestry problems in which they are interested, but also for assistance in many other matters. The efficient and sympathetic handling of forestry problems on the part of the service, in the interest not only of the nation, but particularly of the sections in which the forests are located, gives promise of the successful solution of any problems that may confront us.

In a statement supplementing his letter, Secretary Houston said that among the first of the activities with which he came in contact was the recreational use of the national forests, under which upward of a million persons every year travel, camp, hunt, fish or maintain summer homes and resorts in the forests. The tour of inspection began on the Santa Fe forest, New Mexico, where many summer homes have been built in the mountains. In the Coconino and Tusayan forests, Arizona, which border the famous Grand Canyon, the secretary was particularly impressed, he said, by the necessity of improvements which will make the canyon more accessible to the public and which are being constructed by the forest service on these and other forests as rapidly as funds permit, nearly 3,000 miles of road and 21,000 miles of trail having been built on all of the national forests up to date.

On the Angeles forest, in southern California, the secretary said, he saw a striking illustration of the importance of forest protection of watersheds, which in this locality has contributed to the irrigation development that in twenty years has transformed a desert into one of the most flourishing agricultural sections of the country. He visited some of the 1,100 towns and cities which derive their domestic water supply from national forests and, after crossing the Sierra Nevada range in an automobile that was fitted to the railway with special, flanged wheels, he inspected one of the largest water-power projects on the forests, a fourteen-million-dollar plant operated under permit on the Sierra National Forest. With regard to water-power, development of which is going on actively under the Department of Agriculture's regulations, the secretary said that he saw no need for a change in the existing system of control, except for legislation to permit long-term leasing of water-power sites.

Stock owners in the west, said the secretary, are more than satisfied with the departmental regulations under which improved range conditions are brought about along with the grazing of increasing numbers of livestock, of which more than fifteen million, mainly sheep, cattle and horses, now graze annually on the national forests. In the logging and mill operations on some of the big timber-sale projects in the Douglas fir country of Oregon and Washington, the secretary said, he was enabled to get much first-hand knowledge of fire protection and conservative logging as carried on under government regulation, and he commended the reforestation work for which from ten to fifteen million trees are grown annually in forest service nurseries.

The secretary completed his tour in Montana after he had had a personal insight into practically all of the important activities of the forest service and, as he said, obtained first-hand impressions not only from forest officers, but from all classes of local residents who are affected by the methods and regulations under which the national forests are being administered in every section of the west.

SCIENTIFIC NOTES AND NEWS

The American Society of Zoologists will meet from December 28 to December 31, inclusive, at the State University of Ohio, Columbus, simultaneously with the meeting of the American Association for the Advancement of Science.

Officers of the American Astronomical Society were elected at the Pacific Coast Meeting as follows:

President, Edward C. Pickering.
First Vice-president, W. W. Campbell.
Second Vice-president, Frank Schlesinger.
Secretary, Philip Fox.
Treasurer, Miss Annie J. Cannon.
Councillors, W. S. Eichelberger, J. S. Plaskett, E. B. Frost, Joel Stebbins.

The Swiss Society of the Natural Sciences, the national association for the advancement of science, meets this year at Geneva, from September 12 to 15. It is the ninety-seventh annual meeting of the society and the hundredth anniversary of its foundation, but in view of the existing circumstances this anniversary will be celebrated in only a simple way, and the usual invitations to foreign scientific societies and scientific men are this year omitted. The papers before the general sessions, partly in French and partly in German, are as follows: "New Light in the Investigation of the Jura Mountains," by Professor A. Heim, of Zurich; "Results of Forty Years of Measurements of the Glacier of the Rhone," by Professor E. L. Mercanton, of Lausanne; "An Archipelago of the Pacific," by Dr. Fritz Sarasin, of Basle; and "The International Phyto-geographic Excursion through North America," by Dr. E. Rübel, of Zurich.

Charles Lee Crandall, professor of railway engineering and geodesy in the college of civil engineering of Cornell University, from which institution he graduated in the first class and where he became a teacher in 1872, has retired from active service. Both the university faculty and the trustees have passed resolutions in appreciation of his services to the university.

Dr. Albert C. Seward, professor of botany in the University of Cambridge, has been elected master of Downing College, in succession to the late Professor Howard Marsh.

The Moxon gold medal of the Royal College of Physicians has been awarded to Professor J. J. Déjerine, and the Baly gold medal to Dr. F. Gowland Hopkins.

The Munich School of Technology has conferred its doctorate of engineering on Dr. von Brill, professor of mathematics at Tübingen, and on Dr. Schwager, of the Geological Survey.

Dr. M. Standfuss and Dr. A. Querbain have been made honorary professors in the University of Zurich, the former in entomology, the latter in meteorology.

Dr. Ernst Schmidt, professor of pharmacological chemistry at Marburg, has celebrated his seventieth birthday.

Professor Béhal has been made director of a department for the study of questions of chemical manufacture with special reference to the war, established by the French ministry of commerce in the Paris School of Pharmacy.

Dr. Jakob von Weyrauch, professor of engineering in the Stuttgart School of Technology, has retired from active service.

An action was brought in the Chancery Division by Professor Arthur Schuster, one of the secretaries of the Royal Society, against the publishers and printer of *Pearson's Weekly*, in respect of an article suggesting that Professor Schuster's private wireless apparatus was discovered and "seized." Defendants offered an ample apology, paid the costs, and gave fifty guineas to the Red Cross funds.

Professor E. L. Nichols, of the department of physics of Cornell University, who has leave of absence for the first term of the coming year, will spend that period in the far east.

Dr. A. J. Herbertson, of Wadham College, Oxford, professor of geography in the university, and well known for his contributions to geography and meteorology, died on July 31, at the age of fifty years.

Dr. Edmund Owen, a London surgeon who had made contributions to surgery and anatomy, died on July 23.

THE death is announced in his seventy-second year of Mr. George Newlyn, formerly connected with the Kew Botanical Garden and a writer in popular science.

M. F. P. J. GUÉGUEN, late professor of botany in the School of Agriculture at Grignon, has died at the age of forty-three years.

DR. JIORDANO, professor in the University of Palermo, known for his work on the diseases of miners, died on July 10.

DR. ALFRED SCHLIZ, the German anthropologist, has died at Heilbrun, at the age of sixty-six years.

FOLLOWING out the provisions of the late Mrs. Keenan, who left $300,000 to establish and maintain a free medical dispensary in Milwaukee, a meeting is soon to be held between the trustees of the fund and the city health department to work out the arrangements as contemplated in the will.

DURING the present summer the regents of the University of New Mexico have instituted a survey of the lands in the university state endowment, of which there are nearly 300,000 acres still owned by the university. Charles T. Kirk, of the New Mexico Natural Resources Survey, and John D. Clark, of the department of chemistry at the University of New Mexico, have been placed in charge of the work.

UNIVERSITY AND EDUCATIONAL NEWS

DR. EDGAR NELSON TRANSEAU, now a professor in the Southwestern Normal School, Charleston, Ill., goes to Ohio State University next year as professor of plant physiology.

PROFESSOR ROY H. PORTER, of Iowa State College, has become head of the department of mechanical engineering at the New Hampshire College to succeed Professor Richard E. Chandler resigned. Professor Porter took his B.S. degree in mechanical engineering at the University of Maine in 1906 and the degree of mechanical engineer at Iowa State College in 1912. He has been instructor in mechanical engineering at Iowa State College, was made assistant professor there in 1908 and associate professor in 1913.

AT Bryn Mawr College Dr. Frederick H. Getman, associate professor of chemistry, has resigned, and Dr. James Llewellyn Crenshaw has been appointed associate in physical chemistry. Dr. Crenshaw has been instructor in chemistry in Centre College and in Princeton University. From 1911 to 1915 he has been research assistant in chemistry in the Carnegie Institution of Washington.

DR. P. H. RÖMER, director of the Institute of Hygiene at Greifswald, has been called to Halle as successor to Professor Fränken.

PROFESSOR HARRIES, of Kiel, director of the chemical laboratory, has declined a call to Göttingen.

DR. KONRAD PICHORIUS, professor of ancient history at Breslau, has been appointed professor at Bonn, as successor to Professor Ulrich Wilcken.

DISCUSSION AND CORRESPONDENCE

ELEMENTARY MECHANICS

THE letter of Professors Franklin and MacNutt[1] is a helpful contribution to the discussion of the laws of motion. I wish especially to endorse their remarks upon the law of action and reaction. The idea that action and reaction, because equal and opposite, are balanced forces, is responsible for more confusion, perhaps, than any other error connected with the laws of dynamics. An instance of this occurs in a comparatively recent article in which the author assumes that a body acted upon by an unbalanced force must be retarded by an equal and opposite "ether-friction" in order to satisfy the law of action and reaction; forgetting that if such were the case the force would really be balanced and the body would have no acceleration. The explanations given by Professors Franklin and MacNutt of the second law of motion and of popular and scientific usage regarding the terms mass and weight are also, in the main, calculated to promote clear thinking about these matters. That "the result of weighing a body on a balance scale" is a proper measure of "amount of material," however, certainly requires explanation to the beginner.

The writers apparently attribute to me some

[1] SCIENCE, July 9, 1915, p. 56.

part of the responsibility for the hopeless confusion which they allege exists regarding the distinction between mass and weight. Their own explanation of this matter however differs from mine chiefly in the picturesqueness of the language employed. I have, indeed, recognized[2] that if full rigor is insisted on it is necessary to make a distinction not mentioned by Professors Franklin and MacNutt. The word weight, according to scientific usage, does not usually mean the actual "force with which the earth pulls on a body," but something which differs from this because of the earth's rotation. I have not advocated introducing this distinction in the first explanation of weight to students; but it can not be permanently avoided if any important attainment is reached in the study of dynamics.

Since the writers have referred to me in connection with the meaning of the division by g, I may say that I certainly am not one of those who believe that weight is converted into mass by dividing by g or by any other process. I believe, however, that the fact should be made clear that mass, like any other measurable magnitude, is expressible in different units; and that the reduction from one unit to another involves precisely the same kind of reasoning in the case of mass as in the case of length or velocity. One can not understand the reduction of a length from feet to meters unless he understands the meaning of both the foot and the meter; a similar statement holds concerning the reduction of a mass from pounds to tons, or from pounds to "slugs." Moreover, I see no reason why the unit which has been called the slug should be regarded with ridicule, or even with semi-ridicule. The question of what unit to employ for any given purpose is properly decided by convenience. The convenience of the "slug" is due to two facts—(1) that the pound-force is customarily employed in a great deal of practical work and (2) that the dynamical formulas almost universally used are based upon a relation of units such that *unit force acting upon unit mass causes unit acceleration.* And there should be no more difficulty in understanding the definition of the "slug" than that of the dyne or the "standard pound-force" or any other unit which is defined by an appeal to the law of acceleration.

L. M. Hoskins

[2] Science, April 23, 1915, p. 611.

QUOTATIONS

BRITISH SCIENTIFIC MEN AND THE GOVERNMENT

In addition to appointing committees to consider suggestions or inventions, the Royal, Chemical and Physical Societies have taken steps to obtain registers of their fellows classified according to special knowledge and to scientific services which the fellows are willing, as well as specially qualified, to perform. The idea in each case is to secure cooperation among the fellows of the particular societies, and to examine by means of committees any promising suggestions relating to munitions of war or kindred subjects. No one knows precisely what will be done with the registers when they have been completed. Each society seems to be compiling its list independently and without any clear view of the use which will be made of the experts' services which will become available by the response to its circular. No scheme has yet been put forward by which definite national duties will be assigned to the hundreds of scientific men who are enrolling themselves on the registers of their respective societies. . . .

The laboratories of our universities, university colleges and technical institutions are at the disposal of the government, and in many of them men are devoting twelve hours a day to work in connection with the supply of munitions of war. A few days ago the members of the Royal Institution decided to offer the resources of their laboratories and of the Davy Faraday Research Laboratory to the government for the prosecution of any particular research by officers of the admiralty, war office or ministry of munitions; and the managers invited communication from these departments "in case there is any field of research in relation to or connected with chemical and physical science, or either of them, to which the professors, assistants and staff of the Royal Institution or of the laboratory can usefully direct their attention with the view of

giving assistance to his Majesty's government in the conduct of the war."

We notice that this resolution was sent to the First Lord of the Admiralty, the Minister of War, the Minister of Munitions and the chairman of the Inventions Board of the Admiralty, but we can scarcely suppose that each of these officers of state will act independently in making whatever use is possible of the offer. Mr. Lloyd George has announced in the House of Commons that he has made arrangements with the Secretary of State for War to take over the invention work relating to the munitions of war for the supply of which his department is responsible. He has also arranged with the First Lord of the Admiralty to take over the work relating to new expedients and inventions for purely army purposes which are at present in charge of that department. . . .

Most people assume that these services will be voluntary; and a correspondent directs our attention to the fact that in the forms circulated by the Physical Society in connection with the proposed "War Register," it is stated that: "It is to be understood that all service would be voluntary, and unpaid, being given for the good of the country during this period of emergency." He adds: "I should like to inquire how it comes about that the Physical Society is not in a position to offer remuneration for work of the character specified in the circular on a scale at least bearing a reasonable proportion to the wages paid by the government for the performance of less responsible labor. Is it really for the good of the country that this work should be unpaid?"

Government departments and statesmen find their requests for expert advice and guidance responded to so willingly by scientific men and societies that they overlook the necessity of making any recompense for work done. In the medical services every qualified practitioner receives rank and reasonable pay, while consultants are given generous retaining fees. In legal circles also no advice is expected without a retainer being attached to it; and in this connection we are interested in the announcement that "according to a statement made in the House of Commons Sir John Simon, as attorney-general, drew £18,000 as his remuneration for the past year." It should be unnecessary to urge that the laws of nature are of as much importance as the laws of the land, and that as in the present crisis men of science can be of greater service to the nation than lawyers or politicians, they should receive at least sufficient reward for it to enable them to put aside their daily work in order to take up national duties. There will be no lack of volunteer workers among scientific men, but the state should understand that its responsibility for payment on account of expert opinion is at least as great in the case of science as it is in law, medicine and engineering.—*Nature*.

SCIENTIFIC BOOKS

The Social Problem, A Constructive Analysis. By CHARLES A. ELLWOOD, professor of sociology in the University of Missouri. In the Citizens' Library of Economics, Politics and Sociology. Edited by RICHARD T. ELY, professor of political economy in the University of Wisconsin. New York, The Macmillan Co., 1915. Pp. 249. $1.25.

"The present crisis in our civilization," we are told in the preface of this book, "calls for a reconstruction of our social philosophy." The author confidently undertakes the task. Decay is noted in religious belief, moral ideals, political honor, conflict of classes, the breakdown of regulation and control, the demand for a strong man and centralization in government. "The very forces which undermined Roman civilization, viz., commercialism, individualism, materialistic standards of life, militarism, a low estimate of marriage and the family, agnosticism in religion and ethics, seem to be the things which are now prominent, if not dominant, in Western civilization." Many new problems have suddenly arisen from increase of population, increase of knowledge, intermingling of races and cultures, increasing interdependence of nations, the invention of new machines and various other developments.

Back of these problems lies *the* social problem. Reformers who emphasize special problems do not grasp it. Those whose vision is

limited to national interests or whose point of view is purely economic have not discovered it. Pacifist, eugenist and feminist all miss it. Rather is it known only by those "who are beginning to perceive that the social problem is now what it has been in all ages, namely the problem of the relations of men to one another." These relations are the outcome of concrete historical, physical, physiological, economic and ideal elements. For example, on the historical side the relations of men in western civilization are largely determined by inheritance of Greek, Hebrew, Roman and Teutonic customs and ideals. Briefly attempting to characterize some of the chief contributions of each of these factors, the author endeavors to show how various inharmonious elements in them have combined with specified unfortunate effects of physical and economic influences to produce undesirable conditions in present society. A final chapter, on "The Solution of the Social Problem," lays down a number of precepts. To "solve" the social problem we must take a synthetic view of our social life, avoid revolution and violence, develop sympathy among all classes in the population, advance education, purify family life, control heredity, inculcate social responsibility, stress reason and altruism, support science, readjust the economic system and finally as a means to all this find and train social leaders.

In covering so large a field in so short a volume Professor Ellwood has necessarily dealt in cavalier fashion with most of his topics. In consequence the cautious scientist who looks in this book for adequate proof of all positions taken will be disappointed. The discerning reader, nevertheless, may possibly draw the not-unscientific conclusion from it that the world is still full of a number of things that need careful investigation. It is to be feared, however, that not all into whose hands "The Social Problem" falls will be able to distinguish opinions from generalizations that have been established through the work of numerous investigators.

A. A. Tenney

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SPECIAL ARTICLES

NEW METHODS IN SOIL PROTOZOOLOGY[1]

In the investigation of a problem bearing on the conclusions of Russell and Hutchinson[2] who consider protozoa as one of the limiting factors of bacterial activity and consequently of soil fertility, the authors found it expedient to carry on several preliminary experiments for the purpose of establishing the value of certain newly devised methods.

In view of the fact that the methods employed for counting protozoa have been unsatisfactory even in the hands of such experienced investigators as Rahn,[3] using an application of the bacterial dilution method; Killer[4] plating on solid media; Müller[5] counting protozoa per standard loopful of solution; and numerous others counting the protozoa directly in a drop by means of a microscope; the authors have adapted the well-known blood-counting apparatus (Blutkörperzählapparat) to the counting of protozoa. The principle underlying the use of this instrument is the microscopical observation of a drop of standard size. The organisms may be examined in the stained or unstained, in the living or dead state. Picrosulphuric acid (Kleinenberg) is recommended for killing and rapid staining simultaneously.

The calculation of results is based on the use of a standard stage micrometer, the squares marked on the disc of the slide, and the constant depth of solution under observation, which is .1 mm. Thus no mechanical variation is possible. The advantages of using this apparatus for counting protozoa are as follows:

1. It is a direct method, thus eliminating many errors attending incubation, etc., and the results can be reported immediately.

1 From the laboratories of Protozoology and Soil Bacteriology. Further results of experimentation and a bibliography on soil protozoology and soil sterilization are awaiting publication in coming issue of *Centr. f. Bakt.*, Abt. II.

2 Russell and Hutchinson, *Jour. Agr. Sci.*, 3 (1909), 111; *ibid.*, 5 (1913), 152, etc.

3 Rahn, O., *Centr. f. Bakt.*, II., 36 (1913), 419.

4 Killer, *Centr. f. Bakt.*, II., 37 (1913), 321.

5 Müller, *Archiv. f. Hyg.*, 75 (1912), 321.

2. It is more accurate than any other method in use, because it is a standard instrument and no mechanical variation is possible.

3. It is rapid and saves considerable time in contradistinction to other methods, and the technique is simple. For example, triplicate counts on any medium were recorded in ten minutes.

4. The counts check more closely than those of any other method.

5. It can be used to advantage whether the number of protozoa present be large or small.

6. It can be used for living, killed or stained organisms and permits of a thorough observation of the individual organisms.

Its disadvantages are that the initial cost is greater than that of other methods, and the sample is too small to be representative. The error of count is considerable where the protozoa are very few or many in number. And a number of fields must be counted because of the uneven distribution, if an accurate count is required.

Despite the logical thoroughness of Russell and Hutchinson's work, there appears to be one point which they seem to have neglected. Namely, the production of ammonia, etc., is used as a criterion for measuring the effect of soil protozoa on bacterial activity, while the fungi in the soil, which are known to be capable of producing ammonia,[6] were not taken into account. Thus there is an added unrecognized factor operating in their experiments as well as those of others, *i. e.*, soil fungi.

Taking cognizance of this factor, a method was devised for its elimination, based upon the principle of dilution, in such a way as to reduce the possibilities for the occurrence of fungi. The method of procedure was to pour plates of ten different fungi media in duplicate. These agars were: potato, oat, cornmeal, rice, bean, raisin, apple, synthetic, soil extract and Cook and Taubenhaus's No. 2.[7]

Upon cooling, a block of each medium about 2 cm. square was cut out with a sterile knife, and 1 c.c. of sterile soil extract was introduced by means of a sterile pipette into the cavity formed. A platinum loopful of a three-day-old culture of soil organisms in soil extract, known to contain numerous bacteria, protozoa and fungi, was then carefully rinsed off in the medium occupying the cavity.

At the same time poured plate cultures of one loopful of the three-day-old culture of organisms were made on the ten different agars mentioned above. Likewise after one week poured plate cultures were made on the ten different media by inoculation with one loopful of the solution present in the cavity of the agar plate.

The results show that on the plates where a portion of the agar was removed and 1 c.c. of soil extract substituted, the bacteria and protozoa developed in large numbers, which might in all probability be due to the fact that a large surface is exposed for such a small quantity of media. The important point, however, which is to be noted from this experiment is that despite the fact that suitable media were furnished for the growth of fungi, none was evident, even after thirty days' incubation.

From the observation of the poured plate cultures made from the original three-day-old culture we note that fungi appear after four days upon three out of ten plates; namely, No. 2, synthetic,[8] and raisin agars. The fungi predominating were species of *Penicillium*, *Alternaria* and *Fusarium*.

On the poured plate cultures made from the solution in the cavity of the agar plates, no fungi developed. This experiment was repeated and corroborated the previous results.

Thus it is certain that whereas fungi were present in the original culture the process of high dilution was responsible for their elimination from the specially prepared cavity on the agar plates.

Thus the dilution method followed by the peculiar manner of plating, as outlined, makes it possible to separate fungi from bacteria and

[6] Müntz and Coudon, *Compt. Rend.*, 116 (1893), 395.

[7] Cook and Taubenhaus, Dela. Bull. No. 91 (1911), 11.

[8] Lipman and Brown, N. J. Ann. Rpt. (1908), 132.

protozoa. And as a result of this separation, it is possible to eliminate fungi from experiments involving the effect of protozoa upon bacterial activity, by making a subculture from the fungi-free solution of bacteria and protozoa (in the cavity of the agar plate).

Some studies on the comparative value of different media for the development of soil protozoa, somewhat after the manner of Cunningham and Löhnis[9] and others, were carried out with hay infusion, with and without the addition of .5 per cent. egg albumen (Goodey), peptone, dried blood, soil extract (Löhnis), horse, cow and chicken manures (Martin) and egg albumen. The above media were employed in dilutions of .5 per cent., 1 per cent., 3 per cent., 5 per cent. and 10 per cent.

A condensed table[10] of maximum numbers (counts made on five succeeding days by means of the Blutkörperzählapparat previously described) is given below:

Days	Large Ciliates	Large Flagellates	Small Ciliates	Small Flagellates
1	8,520 in soil ex. 800 cc.	840 in 10 % hay	4,255 in 5% D. B.	28,750 in 5 % D. B.
2	63,800 in horse .5 %	709 in 5 % egg albumen	9,210 in 3% chicken	282,000 in 5 % horse
3	319,010 in 10 % hay	10,625 in 10 % hay	208,000 in 3 % chicken	636,500 in soil ex. 1,000 cc.
4	708,000 in 10 % hay	7,435 in 5 % cow	379,000 in 3 % egg	478,000 in 1 % horse
5	1,410,000 in 10 % hay and egg	319,000 in 5 % cow	804,000 in 3 % egg	1,878,000 in 3 % hay and egg

Summary

1. Ten per cent. hay infusion proved to be the most favorable medium for the development of large numbers of small flagellates, as well as small and large ciliates. Hay infusion in various concentrations, with and without the addition of egg albumen, proved to be well adapted to the development of the organisms. Hay infusion plus .5 per cent. egg albumen proved superior to all other media for the development of ciliates.

2. Soil extract is an excellent medium, though somewhat inferior to hay infusion plus .5 per cent. egg albumen and with the soil used in this experiment lower concentrations than those recommended by Löhnis, developed protozoa in a shorter period of time.

3. Three per cent. chicken manure is an excellent medium for the development of small ciliates.

4. The numbers and species of protozoa which can be obtained from a given soil are largely dependent upon the media employed, time of incubation, as well as the kind of soil used.

5. In general the order of appearance of protozoa was as follows: small flagellates, small ciliates, large flagellates (if appearing at all) and finally large ciliates. This confirms Cunningham and Löhnis's observations.

Nicholas Kopeloff,
H. Clay Lint,
David A. Coleman
New Brunswick, N. J.,
February 25, 1915

[9] Cunningham and Löhnis, *Centr. f. Bakt.*, II., 39 (1914), 596.

[10] Kopeloff, Lint and Coleman, *Am. Mic. Soc.*, 34, No. 2 (1915), 149, *Jour. Agr. Res.*, 4, No. 6 (1915).

SOCIETIES AND ACADEMIES

THE BOTANICAL SOCIETY OF WASHINGTON

The Botanical Society of Washington entertained at an informal dinner at the Cosmos Club, on Thursday evening, July 22, 1915, Dr. F. Kølpin Ravn, of Denmark, Dr. Otto Appel, of Germany, and Dr. Gentaro Yamada, of Japan. Mr. M. A. Carleton welcomed the guests, each of whom responded.

Dr. H. B. Humphrey commented on the services rendered to cereal pathology by Dr. Ravn's travel and studies in the United States this season.

Dr. W. A. Orton gave a full account of the travel of Dr. Appel and his investigations of the potato diseases in this country during the past year.

Dr. E. F. Smith emphasized the importance of wide travel and experience to botanical investigators.

Dr. C. L. Shear spoke on international phytopathology, and expressed a hope that within a short time there may be organized an international society of plant pathologists.

Perley Spaulding,
Corresponding Secretary